Competition and efficiency in the Dutch life insurance industry

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1. Introduction

This article investigates efficiency and competitive behaviour on the Dutch life insurance market. In the Netherlands, the life insurance sector is important with in 2003 a volume of business in terms of annual premiums paid of 24 billion, invested assets of 238 billion and insured capital of 900 billion.[1] This market provides important financial products, such as endowment insurance, annuities, term insurance and burial funds, of often sizeable value for consumers. Financial planning of many households depends on proper functioning of this market. The complexity of the products and dependency on future investment returns make many life insurance products rather opaque. Therefore, competition and efficiency in this sector are important issues, both from the point of view of consumers as well as that of supervisors whose duty it is to protect the interests of consumers.

Most life insurance policies have a long life span, which makes consumers sensitive to the reliability of the respective firms. Life insurance firms need to remain in a financially sound condition over decades in order to be able to pay out the promised benefits. The sector has a safety net arrangement in the case a life insurer fails, but that does not cover all risks and excludes policies of the largest ten firms. Without sufficient profitability it could be questionable whether life insurers are able to face unfavourable developments such as a long-lasting decline of long-term interest rates. Obviously, there may be a complex trade off between increased competition with a short-run advantage for consumers of low premiums, but possibly the drawback of higher long-run risk with respect to the insurance benefits. In practice, the likelihood that an insurer in the Netherlands fails, appears to be rather limited with only one bankruptcy in the last twenty years. Obviously, improvement of efficiency would benefit all stakeholders, both in the short and the long run. Also the impact of competition on this trade off between short and long term interests makes it worthwhile to further investigate competition in this market.

[1] In terms of premiums as a percentage of GDP, the Dutch market is around 40% above the European weighted average.

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Life insurance firms sell different products using various distribution channels, thereby creating several submarkets. The degree of competition may vary across these submarkets. For instance, submarkets where parties bargain on collective contracts (mainly pension schemes provided by the employer) and submarkets for direct writers are expected to be more competitive than submarkets where insurance agents sell products to uninformed but trusting customers. Lack of sufficient data on prices of life insurance products, market shares of products and distribution channels, makes distinctions of competition on submarkets impossible.

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Lack of data also prohibits us to measure competition among life insurers *directly* (for instance, by a price-cost margin), even for the total life insurance market. One qualitative way to investigate this market is to work out what its structural features are, particularly those related to its competitive nature. On the supply side, we find that market power of insurance firms is limited due to their plurality and that ample entry possibilities exist, all of which contributes to sound competitive conditions. But on the demand side, we observe that consumer power is limited, particularly due to the opaque nature of many life insurance products, and that there are few substitution possibilities for life insurance policies, which could hamper increased competition. Combining these various insights, we have reasons to analyse the competitive nature of this market further.

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An often-used quantitative indirect measure of competition is efficiency. Increased competition is assumed to force firms to operate more efficiently, so that high efficiency might indicate the existence of competition and *vice versa*. We distinguish between various types of efficiency, particularly scale efficiency and X-efficiency. Scale economies are related to output volumes, whereas cost X-efficiency reflects managerial ability to drive down production costs, controlled for output volumes and input price levels. There are various methods to measure scale economies and X-efficiency.[2] We use a translog cost function to reveal the existence of scale economies, and a stochastic cost frontier model to

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[2] For an overview, see Bikker (2004) or Bikker and Bos (2005).

measure X-efficiency. Further, large unemployed scale economies may raise questions about the competitive pressure in the market. Note that the existence of scale efficiency is also important for the potential entry of new firms, an important determinant of competition. Strong scale effects would put new firms at a disadvantage.

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A straightforward measure of competition is the profit margin. Supernormal profits would indicate insufficient competition. We observe profits of Dutch life insurers over time and compare them with profits of foreign peers.

Another indirect measure of competition is the so-called Boone indicator. This approach is based on the notion that competition rewards efficiency and punishes inefficiency. In competitive markets, efficient firms perform better – in terms of market shares and hence profit – than inefficient firms. The Boone indicator measures the extent to which efficiency differences between firms are translated into performance differences. The more competitive the market is, the stronger is the relationship between efficiency differences and performance differences. The Boone indicator is usually measured over time, giving a picture of the development of competition. Further, the level of the Boone indicator in life insurances can be compared with levels in other parts of the service sector, to assess the relative competitiveness of the life insurance market.

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Our article is part of a larger research project on competition in the life insurance industry, see CPB. (2005). Other chapters of this report go into more detail with respect to barriers of competition, product choice and the role of financial advice. This article aims at measuring competitive behaviour and performance of the Dutch life insurance market as a whole. The current article is complementary to the detailed studies in the following sense: whatever goes on in the often discussed financial advice part of the business, the current article verifies what can be said about competition on the market on an aggregate level. Any problems (or lack of problems) should ultimately show up in aggregate indicators of competition. Since we use four different empirical aggregate indicators (average profit margins, scale economies, X-inefficiencies and the Boone indicator), we will get a reasonable picture of competition in this market.

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The outline of the article is as follows. Section 2 provides a brief and general explanation of the production of life insurance firms. Section 3 investigates the competitive structure of demand and supply sides of the Dutch life insurance market. Section 4 measures scale economies based on the so-called translog cost function, while the next section introduces the measurement of X-efficiency. Section 6 discusses the Boone indicator. Section 7 describes the data used and Section 8 presents the empirical results of the various indirect measures of competition. The last section sums up and draws conclusions.

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2. The production of life insurances

The core business of insurance firms is the sale of protection against risks.[3] There are two quite different types of insurance products: life insurance and non-life or property & casualty (P&C) insurance.[4] Life insurance covers deviations in the timing and size of predetermined cash flows due to (non-)accidental death or disability. While some life insurance products pay out only in the incident of death (term insurance and burial funds), others do so at the end of a term or a number of terms (endowment insurance).[5] A typical annuity policy pays an annual amount starting on a given date (if a specific person is still alive) and continues until that person passes away. The benefits of insurance can be guaranteed beforehand so that the insurance firm bears the risk that invested premiums may not cover the promised payments. Such guaranteed benefits may be accompanied by some kind of profit sharing, *e.g.* depending on indices of bonds or shares. The benefits of insurance can also be linked to capital market investments, *e.g.* a basket of shares, so that the insurance firm bears no investment risk at all. Such policies are usually referred to as unit-linked funds. We also observe mixed products, *e.g.* unit linked funds with guaranteed minimum investment returns.

[3] For life insurances, a second motive is the accumulation of assets. Some countries see many buyers of annuities eventually cashing out their contracts rather than annuitizing.

[4] In the Netherlands, health insurance is part of non-life insurance, whereas in Anglo-Saxon countries, health insurance is seen as part of life insurance.

[5] A typical endowment insurance policy pays a given amount at a given date if a given person is still alive, or earlier when he or she passes away. Of course, there are many variants to these archetypes.

A major feature of life insurance is its long-term character, often continuing for decades. Therefore, policyholders need to trust their life insurance company, making insurers very sensitive to their reputation. Life insurers need large reserves to cover their calculated insurance liabilities. These reserves are financed by – annual or single – insurance premiums and invested mainly on the capital market. The major risk of life insurers concerns mismatches between liabilities and assets. Idiosyncratic life risk is negligible as it can be well diversified. Systematic life risk, however, such as increasing life expectancy, can also pose a threat to life insurers. Yet their major risk will always be investment risk. The main services which life insurance firms provide to their customers are life (and disability) risk pooling and financial intermediation. Significant expenditures include sales expenses, whether in the form of direct sales costs or of fees paid to insurance agencies, administrative costs, investment management and product development.

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In the Netherlands, the insurance product market is heavily influenced by fiscal privileges. In the past, endowment-insurance allowances, including any related investment income, used to be tax-exempt, up to certain limits, provided that certain none-too-restrictive conditions were met. Annuity premiums were tax deductible, but annuity allowances were taxed. Again this implies that investment income was enjoyed tax-free while consumers could often also benefit from lower marginal tax rates after retirement. In 2001 a major tax revision reduced the tax benefits for all new policies, while the rights of existing policies were respected.[6] The tax reduction was made public in earlier years, so that consumers could bring forward their spending on annuities and insurers were eager to sell. Endowment insurance policies became subject to wealth tax and income tax exemption limits were reduced. At the same time, both the standard deduction for annuity premiums and the permission for individuals to deduct annuity premiums to repair pension shortfalls were also reduced. The reduced subsidy on annuities, in particular, has had a great impact on volumes.

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[6] The fiscal regime change might cause a structural break. However, re-estimation of our model for two sub periods, before and after the change, did not give different results.

Finally, in 2003, the standard deduction for annuity premiums was abolished entirely, whereas the permission to do so on an individual basis was limited even further.

3. The competitive structure of the Dutch life insurance market

This section briefly discusses structural characteristics of the market for life insurance that may affect competition.[7] The diagnostic framework developed in CPB (2003) enables an assessment whether a market structure constitutes a tight oligopoly. The latter is an oligopoly which facilitates the realization of supernormal profits for a substantial period of time, where 'facilitate' reflects that the probability that supernormal profits are observed are higher than in a more competitive market, 'supernormal profits' exceeds a market conform rate of risk-adjusted return on capital, and 'substantial period of time' reflects that oligopolies will be stable for a number of years.

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3.1 Supply side factors

The diagnostic framework mentioned above contains a list of coordinated and unilateral factors that increase the probability of a tight oligopoly, see Table 3.1. Coordinated factors refer to explicit and tacit collusion, while unilateral factors denote actions undertaken by individual firms without any form of coordination with other firms. Economic theory indicates that a high concentration and high entry barriers are conducive to the realization of supernormal profits. Frequent interaction, transparency and symmetry (in terms of equal cost structures) are beneficial to a tight oligopoly since they make it easier for firms to coordinate their actions and to detect and punish deviations from the (explicitly or tacitly) agreed upon behaviour. Heterogeneous products make it easier for firms to raise prices independently of competitors, as consumers are less likely to switch to another firm in response to price differences. Structural links between firms such as cross-ownerships would give firms a stake in each others' performance, thus softening competition.[8] Information about risks plays

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[7] For a fuller discussion we refer to CPB (2005). See also Kamerschen (2004).

[8] For a detailed analysis of the various effects we refer to CPB (2003).

a crucial role in markets for financial products. In the case of life insurance, adverse selection may play a role when consumers have more information regarding their life expectancy than insurance companies. Adverse selection may lead to higher price-costs margins.

Table 3.1 Determinants of competition

	Coordinated factors	Unilateral factors
Supply side factors		
Essential	Few firms	Few firms
	High entry barriers	High entry barriers
	Frequent interaction	Heterogeneous products
Important	Transparency	Structural links
	Symmetry	Adverse selection
Demand side factors		
	Low firm-level elasticity of demand	
	Stable demand	Imperfection in financial advice

Source: CPB (2003), page 34 (except adverse selection).

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An indicator of market concentration or the number of firms, the first determinant of competition, is the Herfindahl-Hirschman Index (HHI).[9] Over 1995–2003 we calculate an average HHI index value of 780 for the Dutch life insurance industry, which is far below any commonly accepted critical value. This low figure reflects also the large number of Dutch life insurance firms, which, over the respective years, ranged from over one hundred to above eighty. An alternative indicator is the so-called k-firm concentration ratio, which sums the market shares of the k largest firms in the market. In 1999, the five largest firms together controlled 66% of the market (see Table 3.2), where the largest firm had a market share of 26%. These figures are not unusual for large countries such as Australia, Canada and Japan, although Germany, the UK and the US have considerably lower ratios. However, one should keep in mind that, by definition, such ratios are substantially higher in smaller markets or

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[9] Concentration ratios are discussed in Bikker and Haaf (2002). $HHI = \sum_{i=1}^{n} s_i^2$ where s_i represents the market share of firm i.

countries. We conclude that insurance market concentration in the Netherlands is moderate, although in market segments, such as collective contracts, concentration may be substantial (CPB, 2005).

The second determining factor of competition is the set of barriers to entry. Table 3.2 shows that the number of entrants as a percentage of the total sample of Dutch insurance firms varied from 2% in 1991 to 8% in 1997. These numbers are relatively high compared to countries such as Canada, Germany and the UK, where the degree of entry varied between 1% and 4%. This suggests that entry opportunities in the Dutch life insurance market seem to be quite large compared to other countries.

Deleted: For discussion on the other supply factors in Table 3.1 we refer to CPB (2005).

Table 3.2 Concentration indices, numbers of firms and numbers of entrants as %

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
5-firm concentration ratio										
France	48.2	48.9	51.3	49.2	48.5	49.6	53.9	53.2	58.4	56.0
Germany	29.9	29.1	29.4	29.6	29.5	29.5	29.1	28.9	29.9	29.4
Netherlands	65.7	63.3	63.6	63.3	63.1	61.4	60.5	59.0	57.7	65.7
UK	36.3	35.3	34.2	38.1	35.9	34.7	35.6	34.8	38.6	
Australia	73.5	70.9	65.8	64.1	61.5	60.0	58.3	61.6	60.0	
US			28.2	27.5	26	25.3	25.7	25.5	25.2	
Canada						65.6	68.4	70.6	73.1	73.3
Japan	63.9	63.6	63.8	63.8	64.1	64.2	63.7	65.1	53.8	
Nr. of firms and new entries										
Germany, nr. of firms	338	342	326	327	319	323	320	319	318	314
Germany, entrants, (%)				0.9	0.9	2.2	1.6	1.3	1.3	1.6
Netherlands, nr. of firms	96	96	97	98	95	96	99	107	108	109
Netherlands, entrants (%)	0.0	4.2	2.1	5.1	5.3	3.1	6.1	8.4	2.8	3.7
UK, nr. of firms	205	202	196	194	191	174	177	177	176	
UK, entrants (%)	4.4	2.0	1.5	2.1	1.0	3.4	1.1	1.1		
Canada, nr. of firms							146	151	150	146
Canada, entrants (%)							2.1	3.3	0.7	0.7
Japan, nr. of firms [10]	30	30	30	30	31	31	44	45	46	47
Japan, entrants (%)	0.0	0.0	0.0	0.0	3.2	0.0	29.5	2.2	2.2	4.3

Source: Group of Ten (2001).

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[10] In 1996 Japanese entrance increased sharply due to a structural change.

3.2 Demand side factors

Coordinated and unilateral demand-side factors also affect the intensity of competition, see Table 3.1. The elasticity of residual demand determines how attractive it is for a firm to unilaterally change its prices. High search and switching costs contribute to low firm-level demand elasticity. Stable, predictable demand makes it easier for firms to collude in order to keep prices high, as in that case cheating by one or more firms will be easier to detect than with fluctuating demand.

In practice, the elasticity of residual demand for life insurance policies is limited, due to in the absence of perfect substitutes. Investment funds or bank savings could in principle be an alternative for old-age savings (such as annuities), but lack the risk-pooling element, which is essential for life insurance policies. Moreover, annuities generally enjoy a more favourable fiscal status related to the tax deductibility of premiums (particularly in the Netherlands, although less since 2001), which is another reason why alternatives are less attractive. A large part of the endowment insurance policies is used in combination with mortgage loans. Here, the importance of risk-pooling is less dominant and may diverge across policyholders, but fiscal treatment with respect to income and wealth taxation is also linked to the life-policy status.

High switching costs are typical for life insurance policies, since contracts are often of a long-term nature and early termination of contracts is costly because it involves disinvestments and a reimbursement of the client to the company of not yet paid acquisition costs, which have a front loading nature.[11]

Search costs for life insurance products are high as these products are complicated and the market is opaque. These costs could be alleviated if search could be entrusted to insurance agents, which would help consumers to avoid errors in their product choice. Moreover, it would make the market more competitive by raising the elasticity of demand. However, the Dutch market for financial advice market may not function properly (CPB,

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[11] Acquisition costs are marketing costs and sales costs, which include commissions to insurance agents.

2005).[12] In particular, due to the incentive structure in this market (notably commissions) coupled with inexperienced consumers, insurance agents may give advice that is not in the best interest of consumers.

Consumer power is weaker as the market is less transparent. Strong brand names are indicators of non-transparency, as confidence in a well-known brand may replace price comparisons or personal judgment. Another indicator is the degree to which buyers organize themselves, for instance, to be informed and to reduce the opaque nature of the market. The major consumer organization in the Netherlands, many Internet sites[13] and other sources such as the magazine Money View, compare prices and inform consumers continuously on life insurance policy conditions and prices in order to enable them to make comparisons and well-founded choices. For a minority of the consumers this is sufficient to take out a life insurance policy as direct writer or at bank or post offices. However, as products remain complicated and come in a great variety of properties (type, age, and so on), the majority of consumers are not able to take out policies themselves, or willing to take the effort, and call upon services of insurance agents. A third indicator is the degree to which consumers can take out life insurance policies collectively. Collective contracts are usually based on thorough comparisons of conditions and prices by experts, are often negotiated via the employer and contribute substantially to consumer power but, of course, many people are unable to take advantage of this instrument to add to consumer power.

Finally, the number of suppliers, which is also an important factor, is sufficiently large, as appears from Table 3.2. All in all, we conclude that buyer power is low as the life

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[12] Incidentally, a new Dutch Financial Services Act (Wet Financiële Dienstverlening) has came into force at the begin of 2006, pressing for more transparency in this market, which may also work to improve competition in this submarket.

[13] See Consumentenbond, 2004, Consumentengeldgids (Personal finance guide), September, 34–37.

[15] This interpretation would be different in a market with only few firms, so that further consolidation would be impossible. Further, this interpretation would also change when new entrees incur unfavourable scale effects during the initial phase of their growth path.

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3.3 Conclusions

The supply side characteristics of the market for life insurance suggest limited supplier power: the number of firms is quite large, the level of concentration is not particularly high and entry opportunities are relatively large. However, at the demand side we find factors high search costs and high switching costs, few substitution possibilities, limited consumer power due to the opaque nature of life insurance products and substantial product differentiation. The demand side conditions may impair the competitive nature of the life insurance market and call for further analysis

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4. Measuring scale economies

In the present market, we expect that scale economies would be reduced under increased competition.[15] The existence of non-exhausted scale economies is an indication that the potential to reduce costs has not been employed fully and, therefore, can be seen as an indirect indicator of (lack of) competition. This is the first reason why we investigate scale economies in this article. A second reason is that we will correct for (potential) distortion by possible scale economies in a subsequent analysis based on the Boone indicator. This correction can be carried out using the estimation results of this section.

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We measure scale economies using a translog cost function (TCF). The measurement and analysis of differences in life insurance cost levels is based on the assumption that the technology of an individual life insurer can be described by a production function which links the various types of life insurer output to input factor prices, such as wages (management), acquisition fees and so on. Under proper conditions, a dual cost function can be derived, using output levels and factor prices as arguments. In line with most of the literature, we use the translog function to describe costs. Christensen *et al.* (1973)

proposed the TCF as a second-order Taylor expansion, usually around the mean, of a generic function with all variables appearing as logarithms. This TCF is a flexible functional form that has proven to be an effective tool for the empirical assessment of efficiency. For a theoretical underpinning and an overview of applications in the literature, see Bikker *et al.* (2006). The TCF reads as follows:

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$$ln\ c_{it} = \alpha + \textstyle\sum_j \beta_j\ ln\ x_{ijt} + \sum_j \sum_k \gamma_{jk}\ ln\ x_{ijt}\ ln\ x_{ikt} + v_{it} \qquad (4.1)$$

where the dependent variable c_{it} is the cost of production of the i^{th} firm ($i = 1, ..., N$) in year t ($t = 1, \ldots, T$). The explanatory variables x_{ijt} represent output or output components ($j, k = 1, ..., m$) and input prices ($j, k = m + 1, \ldots, M$). The two sum terms constitute the multiproduct TCF: the linear terms on the one hand and the squares and cross-terms on the other, each accompanied by the unknown parameters β_j and γ_{jk}, respectively. v_{it} is the error term.

A number of additional calculations need to be executed to be able to understand the coefficients of the TCF in Equation (4.1) and to draw conclusions from them. For these calculations, the insurance firm-year observations are divided into a number of size classes, based on the related value of premium income. The marginal costs of output category j (for $j = 1, ..., m$) for size class q in units of the currency, $mc_{j,q}$, is defined as:

$$mc_{j,q} = \partial\, c \,/\, \partial\, x_j = (c_q \,/\, x_{j,q})\ \partial\, ln\, c \,/\, \partial\, ln\, x_j \qquad (4.2)$$

where $X_{j,q}$ and c_q are averages for size class q of the variables. It is important to check whether marginal resource costs are positive at all average output levels in each size class. Otherwise, from the point of view of economic theory, the estimates would not make sense.

Scale economies indicate the amount by which operating costs go up when all output levels increase proportionately. We define scale economies as:[16]

[16] Note that sometimes scale economies are defined by the reciprocal of Equation (4.3), see, for instance, Baumol *et al.* (1982, page 21) and Resti (1997).

$$SE = \Sigma_{j=1,\ \ ,m}\, \partial \ln c / \partial \ln x_j \qquad (4.3)$$

where $SE < 1$ corresponds to economies of scale, that is, a less than proportionate increase in cost when output levels are raised, whereas $SE > 1$ indicates diseconomies of scale.

The literature provides various examples of diseconomies-of-scale measurement. Fecher *et al*. (1991) applied translog cost functions to estimate scale economies in the French insurance industry. They find increasing returns to scale. However, it is unclear whether this effect is significant. An increase of production by one per cent increases costs by only 0.85 per cent in France's life insurance industry. Grace and Timme (1992) examine cost economies in the US life insurance industry. They find strong and significant scale economies for the US life insurance industry. Depending on the type of firm and the size of the firm an increase of production by one per cent will increase costs by 0.73% to 0.96%.

This article applies two versions of the TCF. The first is used to estimate the scale effects and marginal cost which will also be taken as input for the Boone-indicator model. In this version, production is proxied by *one* variable, namely premium income. Particularly for marginal costs, it is necessary to use a single measure of production, even if that would be somewhat less accurate (see Section 8.1). The second is the stochastic cost approach model, discussed in the next section, which is used to estimate X-inefficiencies. Here it is essential that the multi-product character of life insurance is recognized, so that a set of five variables has been used to approximate production (see Sections 5, 8.2 and 8.3).

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5. Measuring X-inefficiency

It is expected that increased competition forces insurance firms to drive down their X-inefficiency, Therefore, X-efficiency is often used as an indirect measure of competition. X-efficiency reflects managerial ability to drive down production costs, controlled for output volumes and input price levels. X-efficiency of firm i is defined as the difference in costs between that firm and the best practice firms of similar size and input prices (Leibenstein,

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1966). Errors, lags between the adoption of the production plan and its implementation, human inertia, distorted communications and uncertainty cause deviations between firms' performance and the efficient frontier formed by the best-practice life insurers with the lowest costs, controlled for output volumes and input price levels.

Various approaches are available to estimate X-inefficiency (see, for example, Lozano-Vivas, 1998). All methods involve determining an efficient frontier on the basis of observed (sets of) minimal values rather than presupposing certain technologically determined minima. Each method, however, uses different assumptions and may result in diverging estimates of inefficiency. In the case of banks, Berger and Humphrey (1997) report a roughly equal split between studies applying non-parametric and parametric techniques. The number of efficiency studies for life insurers is small compared to that for banks. For a survey, see Cummins and Weiss (2000) and Bikker *et al.* (2006). *Non-parametric* approaches, such as data envelopment analysis (DEA) and free disposable hull (FDH) analysis, have the practical advantage that no functional form needs to be specified. At the same time, however, they do not allow for random error terms, so that specification errors, missing variable and so on, if they do exist may be wrongly measured as inefficiency, raising the inefficiency estimate. The results of the DEA method are also sensitive to the number of constraints specified. An even greater disadvantage of these techniques is that they generally ignore prices and can, therefore, account only for technical, not for economic inefficiency.

One of the *parametric* methods is the stochastic frontier approach, which assumes that the random error term is the sum of a random error term and an inefficiency term. These two components can be distinguished by making one or more assumptions about the asymmetry of the distribution of the inefficiency term. Although such assumptions are not very restrictive, they are nevertheless criticized for being somewhat arbitrary. A flexible alternative for panel data is the distribution-free approach, which avoids any assumption

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regarding the distribution of the inefficiency term, but supposes that the error term for each life insurance company over time is zero. Hence, the average predicted error of a firm is its estimated inefficiency. The assumption under this approach of – on average – zero random error terms for each company is a very strong one, and, hence, a drawback. Moreover, shifts in time remain unidentified. Finally, the thick frontier method does not compare single life insurers with the best-practice life insurers on the frontier, but produces an inefficiency measure for the whole sample. The 25*th* percentile of the life insurer cost distribution is taken as the 'thick' frontier and the range between the 25th and 75th percentile as inefficiency. This approach avoids the influence of outliers, but at the same time assumes that all errors of the 25th percentile reflect only random error terms, not inefficiency.

All approaches have their pros and cons. All in all, the stochastic frontier approach, which has been applied widely, is selected as being – in principle – the least biased. This article will also use this approach. Berger and Mester (1997) have found that the efficiency estimates are fairly robust to differences in methodology, which fortunately makes the choice of efficiency measurement approach less critical.

The stochastic cost frontier (SCF) function[18] elaborates on the TCF, splitting the error term into two components, one to account for random effects due to the model specification and another to account for cost X-inefficiencies:

$$ln\ c_{it} = \alpha + \sum_j \beta_j\ ln\ x_{ijt} + \sum_j \sum_k \gamma_{jk}\ ln\ x_{ijt}\ ln\ x_{ikt} + v_{it} + u_{it} \qquad (5.1)$$

The subindices refer to firms i and time t. The v_{it} terms represent the random error terms of the TCF, which are assumed to be identically and independently $N(0,\sigma_v^2)$ distributed and the u_{it} terms are *non-negative* random variables which describe cost inefficiency and are assumed to be identically and independently half-normally ($|N(0,\sigma_u^2)|$) distributed and to be

[18] The first stochastic frontier function for production was independently proposed by Aigner, Lovell and Schmidt (1977) and Meeusen and Van den Broeck (1977). Schmidt and Lovell (1979) presented its dual as a stochastic cost frontier function.

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independent from the v_{it}s. In other words, the density function of the u_{it}s is (twice) the positive half of the normal density function.

Cost efficiency of a life insurer relative to the cost frontier estimated by Equation (5.1) is calculated as follows. X is the matrix containing the explanatory variables. Cost efficiency is defined as:[19]

$$EFF_{it} = E(c_{it} \mid u_{it} = 0, X) / E(c_{it} \mid u_{it}, X) = 1/\exp(u_{it}) \tag{5.2}$$

In other words, efficiency is the ratio of expected costs on the frontier (where production would be completely efficient, or $u_{it} = 0$) and expected costs, conditional upon the observed degree of inefficiency.[20] Numerator and denominator are both conditional upon X, the given level of output components and input prices. Values of EFF_{it} range from 0 to 1. We define inefficiency as: $INEFF = 1 - EFF$.[21]

The SCF model encompasses the TCF in cases where the inefficiencies u_{it} can be ignored. A test on the restriction which reduces the former to the latter is available after reparameterisation of the model of Equation (5.1) by replacing σ_v^2 and σ_u^2 by, respectively, $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\lambda = \sigma_u^2/(\sigma_v^2 + \sigma_u^2)$, see Battese and Corra (1977). The λ parameter can be employed to test whether a SCF model is necessary at all. Acceptance of the null hypothesis $\lambda = 0$ would imply that $\sigma_u = 0$ and hence that the term u_{it} should be removed from the model, so that Equation (5.1) narrows down to the TCF of Equation (4.1).

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An extensive body of literature is devoted to the measurement of X-efficiency in the life insurance markets, see Bikker *et al.* (2006) for an overview. Most studies estimate efficiency on a single country base, using different methods to measure scale economies and

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[19] This expression relies upon the predicted value of the unobservable, u_{it}, which can be calculated from expectations of u_{it}, conditional upon the observed values of v_{it} and u_{it}, (see Battese and Coelli 1992, 1993, 1995).

[20] Note that the $E(c_{it} \mid u_{it}, X)$ differs from actual costs, c_{it}, due to v_{it}.

[21] An alternative definition would be the inverse of EFF_{it}, $INEFF_{it} = \exp(u_{it})$, which is bounded between 1 and ∞.

X-efficiency of the life insurance industry. Furthermore, the studies employ diverging definitions for output, input factors and input factor prices. Key results of the insurance economies studies are that scale economies exist, that scope economies are small, rare or even negative and that average X-inefficiencies vary from low levels around 10% to high levels, even up to above 50%, generally with large dispersion of inefficiency for individual forms. The studies present mixed results with respect to the relationship between size and inefficiency. The stochastic cost frontier approach is generally seen as more reliable than the non parametric methods, which appear to provide diverging levels and rankings of inefficiencies.

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6. The Boone indicator of competition

Recently Boone has presented a novel approach to measuring competition.[22] His approach is based on the idea that competition rewards efficiency. In general, an efficient firm will realise higher market shares and hence higher profits than a less efficient one. Crucial for the Boone indicator approach is that this effect will be stronger, the more competitive the market is. This leads to the following empirical model:

$$\pi_{it} / \pi_{jt} = \alpha + \beta_t \,(mc_{it} / mc_{jt}) + \gamma\, \tau_t + \varepsilon_{it} \qquad (6.1)$$

where α, β_t and γ are parameters and π_{it} denotes the profit of firm i in year t. Relative profits π_{it} / π_{jt} are defined for any pair of firms and depend, among other things, on the relative marginal costs of the respective firms, mc_{it} / mc_{jt}. The variable τ_t is a time trend and ε_{it} an error term. The parameter of interest is β_t. It is expected to have a negative sign, because relatively efficient firms make higher profits. In what follows we will refer to β_t as the Boone-indicator. Boone shows that when profit differences are increasingly determined by marginal cost differences, this indicates increased competition. The Boone indicator can be used to answer two types of questions. The first type focuses the time dimension of β_t 'how

[22] See Boone and Weigand in CPB (2000) and Boone (2001, 2004).

does competition evolve over time?’ and the second type looks at the potential cross-section nature of Equation (6.1) ‘how does competition in the life insurance market compare to competition in other service sectors?’ Since measurement errors are less likely to vary over time than over industries the former interpretation is more robust than the latter one. For that reason, Boone focuses on the *change* in β_t, over time within a given sector. Comparisons of β_t, across sectors are possible, but unobserved sector specific factors may affect β_t. An advantage of the Boone indicator is that it is more directly linked to competition than measures such as scale economies and X-inefficiency, or frequently used (both theoretically and empirically) but often misleading measures as the concentration index.[23] The Boone indicator requires data of fairly homogeneous products. Although some heterogeneity in life insurance products exists, its degree of homogeneity is high compared to similar studies using the Boone-indicator (*e.g*. Creusen *et al*., 2005).

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We are not aware of any empirical application of the Boone model to the life insurance industry. Boone and Weigand in CPB (2000) and Boone (2004) have applied their model on data from different manufacturing industries. Both papers approximate a firm’s marginal costs by the ratio of variable costs and revenues, as marginal costs can not be observed directly. CPB (2000) uses the *relative* values of profits and the ratio of variable cost and revenues, whereas Boone *et al.* (2004) consider the *absolute* values. To obtain a comparable scale for the dependent variable (relative profits) and the independent variable (relative marginal costs) and to avoid that outliers have to much effect on the estimated slope, these variables are both expressed in logarithms. Consequently, all observations of companies with losses – instead of profits – have been deleted, introducing a bias in the sample towards profitable firms. Boone realizes that this introduces a focus towards

[23] More competition can force firms to consolidate (see our scale economies discussion). Claessens and Laeven (2004) found in a world wide study on banking that concentration was positively instead of negatively related to competition.

profitable firms, but states that the competitive effect of firms with losses is still present in the behaviour and results of the other firms in the sample.[24]

Finally, we adjust the Boone model also by replacing often-used proxies for marginal costs, such as average variable cost, by a model-based estimate of marginal cost itself. We are able to do so using the translog cost function from Section 4. Moreover, this enables us to correct the marginal cost for the effects of scale economies. The correction is based on an auxiliary regression wherein marginal costs are explained by a quadratic function of production. The residuals of this auxiliary regression are used as adjusted marginal costs.

7. Description of the data

This article uses data of the former Pensions and Insurance Supervisory Authority of the Netherlands, which recently merged with the Nederlandsche Bank. The data has been reported by Dutch life insurance companies over 1995–2003 in the context of supervision and consists of 867 firm-year observations. In our dataset, the number of active companies in the Netherlands was 84 in 2003 and 105 in 1998. In 2003, 40 insurers were independent and 46 were owned by 16 different holding companies. Most of the latter 46 subsidiary companies operated entirely or highly independently, hence, also competing with each other. In a few cases, the subsidiary companies were more integrated, so less independent from their holding companies. However, they focussed on different product types, used different distribution channels or operated in different regions, so that the question whether they are competing with one another is less relevant. We conclude that the aggregation of insurers to the holding company level would be less appropriate.

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Deleted: The average size of a life insurance company in terms of total assets on its balance sheets is around 2.5 billion. This firm has around half a million policies in its portfolio, insures a total endowment capital of 7 billion euro and current and future annual rents of almost 400 million euro. Profits are defined as technical results, so that profits arising from investments are included, and are taken before tax. Profits of an average firm amount to 5.5% of their premium income. An average firm uses five percent of its gross premiums for reinsurance. Roughly 63% of premiums are from individual contracts, the remainder is of a collective nature. More than half of the insurance firms have no collective contracts at all. Two-thirds of the contracts are based on periodic payments. Annual premiums reflect both old and new contracts. Because on average 48% of the premiums paid are of the lump sum type, whereas, on average, 15% of the periodic premiums refer also to new policies, the majority of the annual premiums stems from new business. Note that also cost and profit figures are based on a mixture of new and old business. Balance-sheet and profit and loss data for new policies only is not available. So called unit-linked fund policies, where policyholders bear the investment risk on their own deposits (that is, premiums minus costs), have become more popular: 44% of premiums are related to this kind of policies. Endowment insurance is the major product category, as 57% of all premiums are collected for this type of insurance. This type of insurance policy is often combined with a mortgage loan. The total costs are around 13% of the total premium income, half of which consists of acquisition (or sales) costs. The medians and the differences between weighted and unweighted averages reflect skewness in the (size) distributions. Larger firms tend to have higher profit margins and relatively lower acquisition cost, lower management cost, less individual contracts, less periodic payments, more unit-linked funds policies and less endowment policies.

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[24] Suppose that the negative profit firms are price fighters. In a well functioning market the price fighters will influence profitability of the other firms.

Table 7.1 Description of the data on Dutch insurance firms (1995–2003)

	Median	Mean		Standard deviation
		Weighted[a]	*Unweighted*	
Total assets (in million)	521.5	.	2,472.5	6,991.6
Annual premiums (in million)	66.0	.	247.7	588.8
Annual costs, total (in million)	18.2	.	32.8	63.2
Annual profits (in million)	2.6	.	15.7	47.6
Total endowment capital (in million)	2,229		7,376	13,483
Amount of annuity rent[b] (in million)	9		387	1,397
Total unit-linked capital (in million)	67		246	589
Number of policies (in 1000)	168.7		522.4	973.6
Profit/premiums	0.047	0.078	0.055	0.25
Reinsurance ratio	0.013	0.034	0.050	0.11
Acquisition costs/total costs	0.53	0.34	0.53	1.86
Individual contracts ratio	1.00	0.63	0.90	0.21
Periodic payments ratio	0.72	0.52	0.67	0.27
Unit-linked funds ratio	0.25	0.44	0.33	0.32
Endowment premium ratio	0.93	0.57	0.82	0.26
Acquisition costs/premium	0.09	0.06	0.16	0.29
Management costs/premium	0.18	0.13	0.23	0.22
Number of observations per year				
1995	94		2000	94
1996[c]	103		2001	93
1997	104		2002	89
1998	105		2003	84
1999	101		*Total*	*867*

[a] Weighted with the size of insurance firms, in terms of the respective denominator, so, weighted average of 'profit/premiums' is total profits divided by total premiums; [b] Annual payment; [c] Ten new entrees in 1996 and one termination.

The average size of a life insurance company in terms of total assets on its balance sheets is around 2.5 billion (see Table 7.1). This imaginary average firm has around half a million policies in its portfolio, insures a total endowment capital of 7 billion euro and has current and future annual rents of almost 400 million euro. Profits are defined as technical results, so that profits arising from investments are included, and are taken before tax. Profits of an average firm amount to 5.5% of their premium income. An average firm uses five percent of its gross premiums for reinsurance. Roughly 63% of premiums are from individual contracts,

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the remainder is of a collective nature. More than half of the insurance firms have no collective contracts at all. Two-thirds of the contracts are based on periodic payments. Annual premiums reflect both old and new contracts. Because on average 48% of the premiums paid are of the lump sum type, whereas, on average, 15% of the periodic premiums refer also to new policies, the majority of the annual premiums stems from new business. Note that cost and profit figures are also based on a mixture of new and old business. Balance-sheet and profit and loss data for new policies only is not available. So called unit-linked fund policies, where policyholders bear the investment risk on their own deposits (that is, premiums minus costs), have become more popular: 44% of premiums are related to this kind of policies. Endowment insurance is the major product category, as 57% of all premiums are collected for this type of insurance. This type of insurance policy is often combined with a mortgage loan. The total costs are around 13% of the total premium income, half of which consists of acquisition (or sales) costs. The medians and the differences between weighted and unweighted averages reflect skewness in the (size) distributions. Larger firms tend to have higher profit margins and relatively lower acquisition cost, lower management cost, fewer individual contracts, fewer periodic payments, more unit-linked funds policies and fewer endowment policies.

8. Empirical results

8.1 Scale economies

This section estimates scale economies using the translog cost function (TCF). In a later section of this article, the TCF is used also to calculate marginal costs (see Sections 4 and 8.4). For these two purposes, the TCF explains the insurance company's cost by (only) one measure of production, namely premiums. As both scale effects and marginal costs are obtained from the first derivatives of the TCF to production, we will disregard other production measures here. Generally, inclusion of more measures of components of

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production or proxies is common practice in the case of multi-product firms, and has indeed been applied in the X-efficiency models in Sections 8.2 and 8.3.

In the literature, measuring output in the life insurance industry is much debated. Where in many other industries, output is equal to the value added, we can not calculate this figure for insurers, due to conceptual problems.[25] Most studies on the life insurance industry use premium income as output measure. Hirschhorn and Geehan (1977) view the production of contracts as the main activity of a life insurance company. Premiums collected directly concern the technical activity of an insurance company. The ability of an insurance company to market products, to select clients and to accept risks are reflected by premiums. However, premiums do not reflect financial activities properly, as *e.g.* asset management represented by the returns on investment is ignored.[26] Despite shortcomings, in this section we also use premium income as the output measure.

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As our model reads in logarithms, we can not use observations where one or more of the variables have a zero or negative value. Insurance firms may employ various sales channels: own sales organizations, tied and multiple insurance agencies, and other channels, such as banks, post offices, etc. We have to drop observations of firms that do not use insurance agencies and report zero acquisition costs. In this sense, we clearly are left with a subsample of firms.

Table 8.1 presents the TCF estimates. We assume that costs are explained by production (in terms of total premiums), reinsurance and acquisition (proxies of prices of reinsurance and acquisition fees [27]), so that these variables also emerge as squares and in cross-terms. To test this basic model for robustness, we also add four control variables in an extended version of the model. Periodic premium policies go with additional administration

[25] Some insurance firms can approximate their value added by comparing their embedded value over time. These data are not publicly available.

[26] The definition of production of life insurance firms is discussed further in Section 8.2.

[27] The price of management, or wages, has been excluded by applying the two standard properties of cost functions, namely linear homogeneity in the input prices and cost-exhaustion (Jorgenson, 1986).

Table 8.1 Estimation results of the translog cost function [a]

Dependent variable: total costs	Basic model		Extended model	
Explanatory variables:	*Coefficient*	*t-value* [b]	*Coefficient*	*t-value* [b]
Premium income (production)	0.50	**5.5	0.16	1.3
Reinsurance ratio	0.26	**2.6	0.13	0.9
Acquisition ratio	-0.18	-1.3	0.05	0.2
Premium income^2	0.01	**2.6	0.03	**4.9
Reinsurance ratio^2	0.04	0.6	0.01	0.9
Acquisition ratio^2	-0.03	*-1.9	-0.02	-0.7
Premium income * reinsurance ratio	-0.03	**-3.0	-0.01	-1.1
Premium income * acquisition ratio	0.03	*1.7	0.02	0.9
Reinsurance ratio * acquisition ratio	0.01	0.9	0.06	**2.5
Individual premiums ratio			-0.09	-0.7
Periodic premium ratio			0.27	**7.9
Unit-linked fund ratio			-0.05	**-3.1
Endowment insurance ratio			0.15	*2.1
Intercept	2.24	**4.4	4.10	**5.5
Adjusted R^2	0.89		0.89	
Nr. of observations	607		456	
Economies of scale	0.82		0.79	
Idem, small firms (25%)	0.72		0.58	
Idem, small to medium-sized firms (50%)	0.77		0.68	
Idem, medium-sized to larger firms (75%)	0.80		0.74	
Idem, large firms (100%)	0.87		0.90	

[a] All terms are expressed in logarithms; [b] One and two asterisks indicate a level of confidence of 95% and 99%, respectively.

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costs, whereas unit-linked fund policies save costs. The bottom lines of Table 8.1 show that life insurance companies, on average, enjoy scale economies of 18%. Correcting for differences in the product mix or the share of unit-linked funds and so on does not qualitatively change the results. We also calculated average scale economies for various size classes with size measured as the companies' premium income. Scale economies appear to be larger for the smaller size classes. According to the extended model, small firms – in the lowest 25 percentile class – may realize average scale economies of 42%, where large firms – in the highest 25 percentile class – enjoy just 10% economies of scale. Decreasing scale

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economies with firm size have also been found by Fecher *et al.* (1993) for the French life insurance industry. The comparison between the basic model and the extended model makes clear that the average scale economies per size class differ (only) slightly on the model specification. Although the average economies of scale for both models are rather similar, the dependency of the scale economies on size classes in the basic model is less than in the extended model.

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The optimal production volume in terms of gross premium is defined as the volume where an additional increase would no longer diminish marginal costs, so that the derivative of marginal costs is zero. According to the basic model, the optimal size can be calculated as far above the size of all actual life insurance firms.[28] This implies that (almost) all firms are in the (upper) left-hand part of the well-known U-shaped average cost curve. The scale economies suggest that consolidation in the Dutch insurance markets is still far from its optimal level, but, of course, diseconomies of conglomeration and mistakes in post-merger integration can outweigh scale economies.

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The TCF estimates make clear that average scale economies of around 20% are an important feature of the Dutch life insurance industry. These scale economies are generally higher than those found for banks in the Netherlands (*e.g.* Bos and Kolari, 2005) and elsewhere (*e.g.* Berger *et al.*, 1993), but not uncommon in other sectors. Similar figures were found in other countries. Fecher *et al.* (1991) find 15% for France and Grace and Timme (1992) observe 4% to 27% for the US, depending on type and size of firm. The existence of substantial scale economies might indicate a moderate degree of competition, as firms have so far not been forced to employ all possible scale economies.

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8.2 *Cost X-inefficiency*

In this section we apply the stochastic cost frontier model (5.1) to data of Dutch insurance firms. Costs are defined as total operating expenses which consist of two components,

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[28] Of course, the accuracy of this optimal size is limited, as its calculated location lies far out of our sample range.

acquisition cost and other costs. The latter includes management costs, salaries, depreciation on capital equipment, and so on. A further split of 'other cost' in its constituent components would be highly welcome, but is regrettably unavailable. The price of the two input factors, acquisition costs and other costs, has been estimated as the ratio of the respective costs and the total assets. Such a proxy is fairly common in the efficiency model literature, in the absence of a better alternative.

As said, the definition of production of life insurance firms is a complicated issue. Insurance firms produce a bundle of services to their policy holders. Particularly for life insurances, services may be provided over a long period. Given the available data, we have selected the following five proxies of services to policyholders, together constituting the multiple products of insurance firms: (1) annual premium income. This variable proxies the production related to new and current policies. A drawback of this variable might be that premiums are made up of the pure cost price plus a profit margin. But it is the only available measure of new policies; (2) the total number of outstanding policies. This variable approximates the services provided under all existing policies, hence the stock instead of the flow. In particular, it reflects services supplied in respect of all policies, irrespective of their size; (3) the sum total of insured capital; (4) the sum total of insured annuities. Endowment insurances and annuity policies are different products. The two variables reflect the different services which are provided to the respective groups of policy holders; and (5) unit-linked funds policies. There are two types of policies regarding the risk on the investments concerned. These risks may be born by the insurance firms or by the policy holders. The latter type of policies are also known as 'unit-linked'. As the insurance firm provides different services in respect of these two types of policy, we include the variable 'unit-linked funds policies'. Note that these five production factors do not describe the production of separate services, but aspects of the production. For example, a unit linked policy may be of either of an endowment insurance type or an annuity type, so that two variables describe four different types of services.

The five production measures and the two input prices also appear as squares and cross-terms in the translog cost function, making for a total of 35 explanatory variables. Such models have proven to provide a close approximation to the complex multiproduct output of financial institutions, resulting in an adequate explanation of cost, conditional on production volume and input factor prices. In our sample, this model explains 94.0% of the variation in the (logarithm of) cost.[29]

The set of suitable (non-zero) data consists of 105 licensed life insurance firms in the Netherlands over the 1995–2003 period, providing a total of 689 firm-year observations. This panel dataset includes new entries, taken-over firms and merged companies and, hence, is unbalanced.

Table A.1 in Appendix I provides the full set of estimation results (see cost column). Due to the non-linear nature of the TCF it is difficult to interpret the coefficients of the individual explanatory variables. As indicated by γ, 91% of the variation in the stochastic terms (σ^2) of the cost model is attributed to the inefficiency term. A test on the hypothesis that inefficiency can be ignored ($\gamma = 0$) is rejected strongly. The essential results are the cost efficiency values calculated according to Equation (5.2). Table 8.2 provides average values of cost X-efficiency per year and for the total sample (see cost column).

Table 8.2 Average cost X-efficiency in 1995-2003

Year	Cost X-efficiency	Year	Cost X-efficiency
1995	0.716	2000	0.710
1996	0.727	2001	0.729
1997	0.741	2002	0.728
1998	0.724	2003	0.718
1999	0.725	*Total*	*0.724*

The average cost X-*efficiency* is 72%, so that the *inefficiency* is, on average, 28%. That implies that costs are, on average, 28% higher than for the best practice firms, conditional on

[29] This figure is based on the OLS estimates, which provides the starting values of the numerical optimisation procedure. As OLS minimizes the errors terms and maximises the degree of fit, the latter will be lower in the SCF model.

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Table 8.3 Average cost X-efficiency over size classes

Size class	Cost	Average size (× 1000)	Size class	Cost	Average size (× 1000)
1	0.747	13,261	6	0.701	2,107,749
2	0.763	94,904	7	0.742	14,479,608
3	0.731	277,937	*Total average*	*0.724*	*2,447,891*
4	0.693	548,474	*Median*		*519,970*
5	0.696	936,795			

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Table 8.3 shows average cost X-efficiency for seven size classes. Here we observe a clear U-curve for cost efficiency: higher efficiency for small insurance firms, lower efficiency for medium-sized companies and, again, increasing efficiency for larger firms. A possible explanation could be that smaller firms generally profit from their orderly structure and neatly arranged composition of products, so that differences in managerial inability across smaller firms are limited (as has also been found for banks, see Bikker, 2004, page 209 *ff.*). The largest firms operate more on competitive submarkets such as pensions and on the more competitive international markets, which have forced them to become more efficient.

8.4 Profitability

A straightforward measure of competition is the profit margin. Supernormal profits would indicate insufficient competition. A traditional measure of profitability is the price-cost margin.[30] We cannot calculate the price-cost margin for life insurance companies, as we do not know the output prices and market shares of all insurance products per firm. However, we are able to calculate the average profit margin, defined as the ratio of profits before taxes and gross premium written. Using figures on consolidated life insurance firms from the ISIS dataset, we compare the Netherlands with some major European economies (see Table 8.4).[31] We are aware that profits could be influenced by differences in accounting rules, products, distribution channels, maturity or other characteristics of the markets.[32] However, we draw some conclusions from the remarkable profit margins in the Netherlands (around 9%) compared to those in other EU countries like France, Germany, Italy and the UK, with respective profit margins of around 7%, 2%, 5% and 4%. The higher profits in the

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[30] This measure can be defined as $PCM = \sum_{i=1}^{n} s_i\,(p_i - mc_i)/p_i$ where p_i denotes the firm's equilibrium output price and mc_i its marginal cost.

[31] ISIS data concern both domestic and foreign activities. Pure domestic figures would be more precise but are not available.

[32] For instance, firms in the Netherlands use more agents as selling channel than those in other countries (CEDA, 2004, page 144).

Netherlands suggest less competition than in the other countries.[33] The Dutch profit margins may be exaggerated, because the ISIS dataset does include fewer small life insurance companies, but this phenomenon also holds for the other countries.

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Table 8.4 Average profit margins of life insurance firms in various countries in % [a]

	ISIS [b]					DNB
	Germany	*France*	*UK*	*Italy*	*The Netherlands*	*The Netherlands*
1995	2.2	—	5.0	—	—	8.1
1996	2.3	12.9	4.2	—	10.2	8.1
1997	2.6	6.3	4.9	7.2	8.1	7.3
1998	2.9	5.6	5.1	5.3	10.0	6.6
1999	3.0	5.8	3.9	4.2	12.6	7.1
2000	2.0	6.9	3.1	6.1	12.0	7.3
2001	1.3	6.2	2.4	4.7	10.9	6.8
2002	1.6	2.1	1.0	2.8	2.2	3.2
2003	—	—	—	—	—	8.9

[a] Weighted averages; [b] Sources: Own calculations based on ISIS (first columns) and DNB (last column).

We also have data published by De Nederlandsche Bank (DNB, the Dutch supervisory authority on insurance companies), which includes all licensed firms and refer to domestic activities only. These figures also point to high Dutch profit margins of around 7%.

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Of course, these figures largely reflect profit margins on past production, as profit stems from the existing portfolio of policies and not only from new business.[34] Sources at hand of specialized on-site supervisors indicate that profit margins of domestic production have declined strongly in recent years. Where Table 8.4 concludes that in the past competition in the Dutch market has been weak, this probably has changed in recent years.

8.5 The Boone indicator

Table 8.5 presents estimates of the Boone indicator, based on an extended version of Equation (6.1) with profits and marginal costs in logarithms. Marginal costs are represented

[33] A similar picture emerges from figures of CEDA (2004), page 198.

[34] This lagging adjustment of profitability does not disturb the international comparison, as this limitation holds also for the foreign data.

in three ways: average variable cost, defined as management costs as share of the total premium as in the traditional Boone model (see *e.g.* Boone, 2004; Creusen *et.al.*, 2004), marginal cost, derived from the translog cost function of Section 8.1, and adjusted marginal costs, *i.e.* marginal costs adjusted for scale economies (see Appendix II).[35] Average variable costs have the advantage of being less complex, since they are not model based, but they are less accurate because we can not distinguish between variable and fixed costs. In practice, average variable costs are commonly proxied by average costs. We prefer the marginal cost derived from a translog cost function, as this is the most accurate measure. Adjusted marginal costs allow one to distinguish between the effects of two components of marginal cost, namely scale economies and X-efficiency.

Table 8.5 Fixed effects estimates of the Boone model for profits [a]

	Average variable cost		**Marginal cost**		**Adjusted marginal cost [b]**	
	Coefficient	*t-value [c]*	*Coefficient*	*t-value [c]*	*Coefficient*	*t-value [c]*
Resp. average variable and marginal cost, in 1995 (β)	-0.52	**-2.7	-0.53	**-2.5	-0.32	-1.4
Idem, 1996	-0.42	*-2.2	-0.38	*-1.8	-0.20	-0.9
Idem, 1997	-0.43	*-2.0	-0.32	-1.3	-0.05	-0.2
Idem, 1998	-0.69	**-3.2	-0.70	**-2.9	-0.23	-0.9
Idem, 1999	-0.34	*-1.7	-0.35	-1.5	-0.08	-0.3
Idem, 2000	-0.43	*-2.1	-0.38	-1.5	-0.10	-0.4
Idem, 2001	-0.55	**-2.7	-0.42	*-1.7	-0.15	-0.6
Idem, 2002	-0.17	-0.9	0.14	-0.5	0.39	1.3
Idem, 2003	-0.37	*-1.7	-0.18	-0.7	0.35	1.2
Individual premiums ratio	1.71	**3.0	1.46	**2.4	1.42	*2.3
Periodic payments ratio	0.34	0.9	0.26	0.6	0.14	0.4
Unit-linked funds ratio	0.22	0.6	0.34	0.8	0.34	0.8
Endowment insurance ratio	-0.27	-0.4	-0.25	-0.3	-0.52	-0.7
Intercept	6.76	**8.1	7.48	**7.4	8.15	**11.5
σ_u	2.01		1.97		0.25	
σ_e	0.66		0.67		0.11	
ρ	0.90		0.89		0.84	
Overall R^2	0.01		0.01		0.00	
Within/between R^2	0.26	0.04	0.28	0.04	0.26	0.08
Nr. of observations (groups)	500	(89)	444	(85)	444	(85)

[a] Profits and marginal costs are in logarithms; [b] Adjusted for scale economies; [c] One and two asterisks indicate a level of confidence of 95% and 99%, respectively.

[35] Note that the variable cost may change over the size classes due to scale efficiency (just as the marginal cost may do), so that the *average* variable cost may differ from the marginal cost. Apart from this theoretical dissimilarity, these variables are also measured differently in practice.

Deleted: Following Boone (2004) and Creusen *et al.* (2004), we also introduce so-called fixed effects, that is, a dummy variable for each insurance firm (coefficients of these dummies are not reported here). The advantage is that these fixed effects pick up all company-specific characteristics, including scale, that are not captured by the other variables, so that part of the disturbances is eliminated. Around 10% of the variance in the error term of the model ¶

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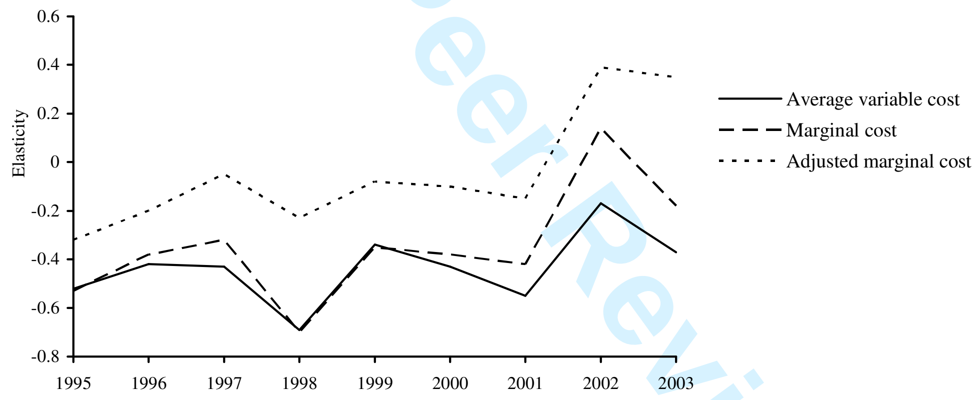
Following Boone (2004) and Creusen *et al.* (2004), we also introduce so-called fixed effects, that is, a dummy variable for each insurance firm (coefficients of these dummies are not reported here).[36] The advantage is that these fixed effects pick up all company-specific characteristics, including scale, that are not captured by the other variables, so that part of the disturbances is eliminated. Around 10% of the variance in the error term of the model without fixed effects (unexplained variance: σ_u^2) can be explained by these fixed effects (explained variance: σ_e^2) when they are introduced, where ρ is equal to $\sigma_u^2/(\sigma_u^2 + \sigma_e^2)$. With respect to the control variables, we find a systematic, significantly positive contribution of individual policyholders to profits. The other control variables, policyholders with periodic payments, unit-linked fund policies and endowment insurances, do not affect profits.

As indicators of competition, the annual estimates of beta are, of course, pivotal in the analysis. The first two columns of Table 8.5 present estimates of beta based on average variable costs, which range from -0.2 to -0.7 and are significant in all years but one. The model-based marginal costs estimates are slightly higher and only significant in four out of nine years. Although the level of the indicator is difficult to interpret, its low degree of significance suggests moderate competition. When marginal costs are adjusted for scale economies, none of the betas are significant. This indicates that scale economies are an important component of the observed Boone indicator. Figure 8.1 shows that the coefficient β fluctuates somewhat over time in all three model versions. We observe an upward trend, indicating a (slight) decline in competition over the respective years. Average variable costs and model-based marginal costs result into similar estimates. The third measure of marginal cost renders a comparable pattern over time, but – due to the eliminated scale economies – at a higher level.

[36] We have also estimated random effect models for profits (Table 8.5) and markets shares (Table 8.6). Their coefficients were quite similar to those of the fixed effect models, with even slightly higher values and higher levels of significance. This suggests that the estimates presented in Tables 8.5 and 8.6 are quite robust. We tested for random effect using the Hausman test, but this test appeared to be undefined, suffering from the 'small sample problem'. All models include year dummies, also not shown in the tables.

In order to assess whether our estimates for the Boone indicator are high or low, we compare them with estimates for other Dutch industries. Creusen *et al.* (2005) estimated the traditional Boone model for the manufacturing and service industries and found elasticities between average variable costs and profits of around, respectively, -5.7 and -2.5, for the years 1993-2001. The Boone indicator of the life insurance industry is around -0.45. As noted in section 6, comparisons of the Boone indicator across sectors are problematic due to measurement error, for example due to differences in accounting practises of profits and losses. However, the absolute value of the Boone indicator of insurances appears to be much lower (closer to zero) than in other service industries. Moreover, estimations using exactly the same definition for profit as in Creusen *et al.* (2005) render the same conclusion.[37] All in all, this implies that the life insurance industry is less competitive than the manufacturing and service industries.

Figure 8.1 Effect on profits of average variable costs and (adjusted) marginal costs



Due to the logarithmic specification of the Boone model, all loss-making firms, including new entrants, have been ignored. This creates a potential bias because 20% of our

[37] The value of the Boone-indicator in these estimations is around -0.85. Results can be obtained from the authors.

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observations concerned loss-making companies. Estimations of the Boone indicator in a model with ratios instead of logarithms using the full sample results in a significant more negative relationship between efficiency and profits. Solving this bias would at most add -0.5 to the Boone indicator. The conclusion remains that the Boone-indicator is substantially smaller in the life insurance industry than in other service industries. Furthermore, the Boone indicator is subject to the same deficiencies as the profit margin in Section 8.4, as it is based on profitability of past business instead of only new production. The next section solves these issues by analysing another performance indicator: market shares. Note that similarly to the description above for profits, market shares will react stronger on marginal costs, the more competitive the market is. Market shares are based on annual premiums and a significant part, 55% of these premiums, are due to new policies. Therefore, market shares reflect largely the current business. Furthermore, using market shares, we can utilize information of the full sample, loss-making firms included.

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8.6 Sensitivity analysis: the Boone indicator based on markets shares

Although the indicator as originally formulated by Boone is based on relative profits, the idea behind it – namely that competition rewards efficiency – implies that we could also use the intermediate magnitude relative market shares as our outcome variable. Therefore, as a check on the findings in the previous section, this section presents estimation results based on markets shares. Results are shown in Table 8.6. We find that average variable costs appear to have a significantly negative effect on market shares, see the first two columns. An increase of this marginal cost measure by one percent results in a market share loss of around 0.45%. Note that this value is similar to the Boone indicator based on profits in Section 8.5.

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If we consider changes in β_1 over time, we observe larger negative values in the years just before the major fiscal policy change-over of 2001 with respect to annuities, as described in Section 2 (see also Figure 8.2). This indicates that competition has intensified somewhat in these years, probably with respect to annuities, which is in line which the observed increase in advertising and sales. In the subsequent years, we see that the effect of marginal costs on market shares decreases, pointing to weakening competition.

Table 8.6 Fixed effects estimates of the model for market shares [a]

	Average variable cost		Marginal cost		Adjusted marginal costs [b]	
	Coefficient	*t-value* [c]	*Coefficient*	*t-value* [c]	*Coefficient*	*t-valu*
Respectively, average variable and (adjusted) marginal cost, in 1995 (β_1)	-0.36	**-5.4	-0.37	**-7.0	-0.18	*
Idem, 1996	-0.45	**-7.3	-0.44	**-7.5	-0.26	**-
Idem, 1997	-0.50	**-7.8	-0.48	**-7.1	-0.25	**-
Idem, 1998	-0.47	**-6.8	-0.44	**-5.5	-0.19	*-
Idem, 1999	-0.57	**-7.9	-0.56	**-7.2	-0.11	-
Idem, 2000	-0.59	**-8.3	-0.59	**-5.9	-0.38	**-
Idem, 2001	-0.48	**-6.6	-0.42	**-2.8	-0.23	*-
Idem, 2002	-0.34	**-5.2	-0.34	*-2.2	-0.10	
Idem, 2003	-0.33	**-4.4	-0.28	*-1.9	0.02	
Individual premiums ratio	0.62	**2.9	0.74	**3.0	0.66	**
Periodic payments ratio	-0.71	**-5.3	-0.70	**-6.2	-0.82	**-
Unit-linked funds ratio	0.45	**3.3	0.56	**4.3	0.59	**
Endowment insurance ratio	0.63	**2.9	0.40	1.0	0.25	
Intercept	-7.13	**25.7	-6.81	**21.5	-6.03	**-2
σ_u	2.11		1.86		1.95	
σ_e	0.30		0.29		0.31	
ρ	0.98		0.98		0.98	
Overall R^2	0.19		0.10		0.02	
Within/between R^2	0.30	0.17	0.28	0.11	0.19	0
Number of observations (groups)	651	(101)	581	(96)	581	(

[a] Market shares and marginal costs in logarithms; [b] Adjusted for scale economies; [c] One and two asterisks indicate a level of confidence of 95% and 99%, respectively.

Considering the other estimation results in Table 8.6, it is clear that the unit-linked funds appear to have been a major innovation in gaining market shares.[39] Collective contracts are

[39] The elasticity of this variable is the coefficient (0.45) times the average of the unit-linked fund ratio (0.33; see Table 7.1), so 0.15.

Deleted: Considering the other estimation results in Table 8.6, it is clear that the unit-linked funds appear to have been a major innovation in gaining market shares. Collective contracts are also favourable for gaining larger market shares. The year dummies are (almost) insignificant and, therefore, have not been shown in the table. When – as a second test on robustness – the four control variables are dropped, we find similar results for β_1 (not reported here). The most important conclusion is that the central results – significant negative values for the β_1s and a (negative) peak in the β_1 just before the fiscal reform of 2001 – appear to be robust for specification choices.¶
The two middle columns of Table 8.5 repeat the results for marginal cost instead of average variable cost. The values of β_1 are similar in level and development over time and slightly less significant.[38] Apparently, average (variable) costs do well as a proxy for marginal costs. The control variables have effects in line with earlier results.¶
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The two middle columns of Table 8.5 repeat the results for marginal cost instead of average variable cost. The values of β_1 are similar in level and development over time and slightly less significant.[40] Apparently, average (variable) costs do well as a proxy for marginal costs. The control variables have effects in line with earlier results.

Although the results presented above uniformly indicate that efficiency gains lead to larger market shares, this could also fully or partly be due to scale economies, as observed in Section 8.1. Large firms enjoy these scale economies which reduce marginal costs and work to increase market shares. To avoid possible distortion due to this kind of endogeneity, we correct the marginal costs (*mc*) for scale economies as set out in Appendix II. This correction for scale economies yields the purest method of investigating the present relationship. The right-hand side columns of Table 8.5 present the estimates for the market share model based on marginal cost adjusted for scale economies. As in the earlier model versions, we find that higher marginal cost tend to diminish a firm's market share and *vice versa*. However, the value of β_1 and its level of significance are much lower now (namely around -0.2), apparently due to the fact that the positive contribution of scale economies has been eliminated (see also Figure 8.2). Note that this coefficient may also be affected by measurement errors. Nevertheless, if we estimate one single β_1 for the whole period, this coefficient is significant (not reported). The control variable coefficients are similar to earlier results. The conclusion is that even after correcting for scale economies, efficiency gains still tend to increase market shares, although its contribution is smaller.

[40] In the basic model, the β_1 values for mc are lower than for average variable costs (namely around -1) and for one year even not significant, see Table A.2 in the appendix.

Figure 8.2 Effect on market shares of average variable costs and (adjusted) marginal costs

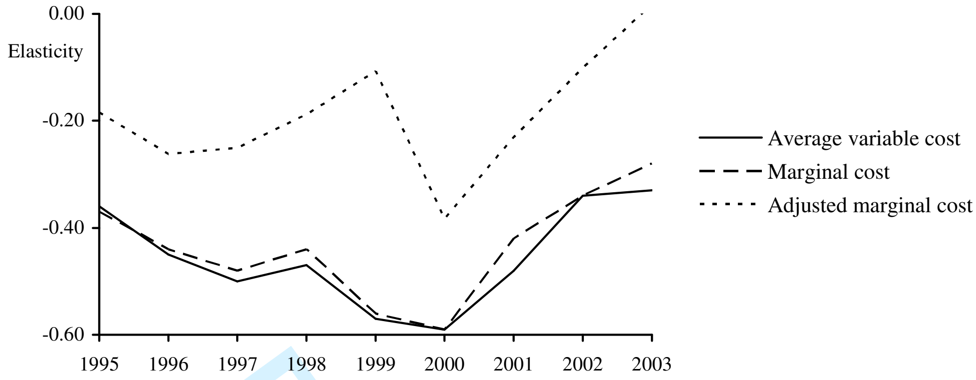

Figure 8.2 shows that the annual estimates of beta in each of the three model versions indicate no upward or downward trend. Higher negative values of β are found in the years just before the major fiscal policy change-over of 2001 with respect to annuities, as described in Section 2. This indicates that competition has intensified somewhat in these years with respect to annuities, which concern around 30% of the market. In the subsequent years, we see that the effect of marginal costs on market shares decreases, pointing to weaker competition. In these years, profit margins on annuities recovered (according to sector experts). Apparently, the level of competition changed somewhat over time.

9. Conclusions

This article analyses competition and efficiency in the Dutch life insurance market. As competition cannot be observed directly, we use five indicators to estimate competition in an indirect manner.

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The *first* indicator is of a qualitative nature. We investigate the structure of the insurance market using the so-called tight oligopoly analysis, yielding diverging results. For the supply side factors we find that supplier power is limited, due to the large number of insurance firms, and that ample entry possibilities exist, which in principle enable sound competition. However, on the demand side we observe that consumer power is limited, particularly due to the opaque nature of many life insurance products, and that few substitution possibilities exist for life insurance policies, which may rein in competition. In short, the resulting overall picture from these considerations is mixed.

The second indicator is the scale efficiency level. A translog cost function has been applied to measure scale economies in the Dutch life insurance industry. Estimates indicate that scale economies exist and amount to 20% on average, ranging from 10% for large firms to 42% for small firms. Such scale economies are substantial compared to what has been found in other countries and to what is usually found for other financial institutions such as banks. All existing insurance companies are far below the estimated (theoretical) optimal size, so that further consolidation in the Dutch life insurance market might be beneficial. Apparently, competitive pressure in the insurance market has so far been insufficient to force insurance firms to exploit these existing scale economies. Of course, consolidation could interfere with entry of new competitors.

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The third indicator is the X-efficiency level. We find cost X-inefficiency estimates of around 25%, on average, a magnitude which would not be expected in a market with increased competition. Incidentally, such inefficiencies are not uncommon for life insurance in other countries or other financial institutions.

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The *fourth* indicator is the profit margin. We observe that profit margins of the Dutch life insurance firms have been high compared to those of their peers in other European countries. This could indicate relatively less competitive pressure in the Netherlands. However, this result mainly reflects the competitive situation in the past rather than in the most recent years. Anecdotical evidence states that current profit margins in the domestic market are small, whereas, given the current low interest rates, the outlook for the (near) future is also not favourable.

The *fifth* indicator is the Boone indicator. Estimates of this indicator point to weak competition in the Dutch life insurance industry in comparison to indicator values in other service industries. All our empirical analyses are based on balance sheet and profit and loss data from both new and old business. Although the majority of annual premiums stems from new policies, the portfolio of policies is built up over the years. Hence, eventual improvement of competition shows up in these figures only with some delay, depending on the approach. However, annual estimates of the Boone indicator for the most recent years find a weakening rather than a strengthening of competition.

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The evidence in this article does not allow us to draw strong conclusions on competition in the insurance market. The reason is that our analysis is on an aggregate level and disregards potentially relevant details with respect to *e.g.* product markets, distributional channels and fiscal treatment, due to lack of data. Yet, all five indicators point to a lack of competition.

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Deliberations about possible policy measures to promote competition in the life insurance market should take into account the trade-off that exists between heavier competition, with the advantage of lower premiums and better services for consumers in the short run, and its downside, the possibility of a long-term deterioration in insurers' solvency, leading to less assured future insurance benefits. Further, possible policy measures should be aimed at the right submarkets or distribution channels. Due to data limitations, our analyses could not distinguish between life insurers and independent insurance agents. Recent research has revealed that the financial advice market does not function properly and may hamper competition. This may be an important indication of where to start enforcing of competition.

Beside, it seems obvious that reduction of both X-inefficiency and scale inefficiency would be advantageous for all parties involved. Developments in information technology make further improvements in efficiency possible. Our empirical research suggests that consolidation might carry substantial cost savings. A comparison with other countries

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teaches that foreign markets are much more consolidated, so that scaling-up in the Dutch market is apparently lagging. From that perspective and given the observed potential savings, further consolidation would be sensible.

Acknowledgements

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APPENDIX I Estimation results

Table A.1 Estimation results of the cost and profit X-efficiency models for insurance firms

Variables	*Coefficients*	*t-values* [a]
Intercept	4.020	**5.1
Premiums (1)	0.149	0.9
Unit-linked funds (2)	0.317	**4.5
Numbers of policies (3)	-0.178	-1.3
Endowment insurance (4)	0.305	**3.4
Amount of annual annuities (5)	0.267	**4.0
Price of acquisition (6)	0.181	1.5
Price of other cost (7)	1.630	**8.0
Netput profit (8)	-	-
Squares (1)	-0.054	**-2.6
Squares (2)	0.000	0.0
Squares (3)	-0.005	-0.4
Squares (4)	0.013	**2.5
Squares (5)	0.004	1.5
Squares (6)	0.038	**5.3
Squares (7)	-0.058	**-4.0
Squares (8)	-	-
Cross-terms (1, 2)	0.039	**4.4
Cross-terms (1, 3)	0.084	**3.4
Cross-terms (1, 4)	-0.018	-1.3
Cross-terms (1, 5)	0.014	1.0
Cross-terms (1, 6)	0.025	1.2
Cross-terms (1, 7)	-0.103	**-3.4
Cross-terms (1, 8)	-0.028	**-3.9
Cross-terms (2, 3)	-	-
Cross-terms (2, 4)	-0.006	*-2.3
Cross-terms (2, 5)	-0.008	**-3.0
Cross-terms (2, 6)	0.020	**3.7
Cross-terms (2, 7)	0.032	**3.9
Cross-terms (2, 8)	-	-
Cross-terms (3, 4)	-0.035	-1.6
Cross-terms (3, 5)	-0.021	**-2.6
Cross-terms (3, 6)	-0.019	-1.2

Cross-terms (3, 7)	-0.105	** -4.6
Cross-terms (3, 8)	0.009	1.1
Cross-terms (4, 5)	-	-
Cross-terms (4, 6)	0.020	** 2.5
Cross-terms (4, 7)	-0.022	-1.1
Cross-terms (4, 8)	-	-
Cross-terms (5, 6)	-0.009	-1.5
Cross-terms (5, 7)	0.052	** 6.1
Cross-terms (5, 8)	-	-
Cross-terms (6, 7)	0.004	0.3
Cross-terms (6, 8)	-	-
Cross-terms (7, 8)	-	-
σ^2	0.952	8.0
γ	0.914	52.6
μ	-1.865	-7.1

[a] One and two asterisks indicate a level of confidence of 95% and 99%, respectively.

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Appendix II Marginal costs adjusted for scale economies

Section 8.1 has confirmed the existence of substantial scale economies in the Dutch life insurance industry. To avoid possible distortion due to endogeneity, we correct the marginal costs (*mc*) for scale economies, based on a simple regression of *mc* on production, where *mc* occurs both in linear terms and squared, either as logarithms or in their natural form (the former for the market share model, the latter for the profit margin model). Table A.2 shows that a one per cent increase in production reduces marginal costs by, on average, 0.15% according to the log-based model and 0.17% in the second model.[41] These figures are in line with the scale economies of Section 8.1. The residuals of these auxiliary equations are interpreted as marginal costs corrected for scale economies.

[41] The elasticity, the first derivative of the auxiliary equation in logs, is -0.37+0.01*2*average production in logarithms. For the auxiliary model in natural values it is equal to $\partial mc/\partial production$ * (average *production* / average *mc*) = (-0.134e-7 + (0.249e-14* 247707.4*2) * 247707 / 0.18.

Table A.2 Auxiliary regressions for marginal cost and scale economies corrections

	Model in logarithms		**Model in natural values**	
	Coefficient	*t-value* [b]	*Coefficient*	*t-value* [b]
Production	-0.37	**-4.5	-1.34 [a]	**-6.3
Production^2	0.01	**2.7	2.49 [a]	**4.6
Intercept	0.83	*1.9	0.20	**31.5
Adjusted R^2	0.19		0.07	
Number of observations	607		607	

[a] In billions instead of in thousands of euros; [b] One and two asterisks indicate a level of confidence of 95% and 99%, respectively.

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2000	0.710
2001	0.729
2002	0.728
2003	0.718
Total	*0.724*

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5	0.696	936,795
6	0.701	2,107,749
7	0.742	14,479,608
Total		*2,447,891*
average	*0.724*	

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	Cost		**Profit**	
Variables	*Coefficients*	*t-values* [a]	*Coefficients*	*t-values* [a]
Intercept	4.020	**5.1	-4.235	**-4.2
Premiums (1)	0.149	0.9	0.079	0.3
Unit-linked funds (2)	0.317	**4.5	-0.160	-1.4
Numbers of policies (3)	-0.178	-1.3	0.141	0.6
Endowment insurance (4)	0.305	**3.4	1.172	**7.0
Amount of annual annuities (5)	0.267	**4.0	0.021	0.2
Price of acquisition (6)	0.181	1.5	-0.690	**-3.1
Price of other cost (7)	1.630	**8.0	1.951	**5.0
Netput profit (8)			-0.262	**-3.0
Squares (1)	-0.054	**-2.6	-0.025	-0.7
Squares (2)	0.000	0.0	0.012	**3.4
Squares (3)	-0.005	-0.4	0.073	**2.9
Squares (4)	0.013	**2.5	0.044	**5.4
Squares (5)	0.004	1.5	0.018	**4.1
Squares (6)	0.038	**5.3	0.027	**2.6
Squares (7)	-0.058	**-4.0	-0.029	-1.2
Squares (8)			0.131	**13.3
Cross-terms (1, 2)	0.039	**4.4	-0.006	-0.5
Cross-terms (1, 3)	0.084	**3.4	0.085	*2.0
Cross-terms (1, 4)	-0.018	-1.3	0.021	0.8
Cross-terms (1, 5)	0.014	1.0	-0.039	*-1.7

Cross-terms (1, 6)	0.025	1.2	0.017	0.5
Cross-terms (1, 7)	-0.103	**-3.4	0.051	0.9
Cross-terms (1, 8)	-0.028	**-3.9	-0.023	-1.4
Cross-terms (2, 3)			-0.006	-0.6
Cross-terms (2, 4)	-0.006	*-2.3	0.012	**2.3
Cross-terms (2, 5)	-0.008	**-3.0	-0.002	-0.5
Cross-terms (2, 6)	0.020	**3.7	0.021	**2.4
Cross-terms (2, 7)	0.032	**3.9	-0.013	-1.0
Cross-terms (2, 8)			0.001	0.1
Cross-terms (3, 4)	-0.035	-1.6	-0.207	**-5.4
Cross-terms (3, 5)	-0.021	**-2.6	-0.033	**-2.4
Cross-terms (3, 6)	-0.019	-1.2	-0.020	-0.7
Cross-terms (3, 7)	-0.105	**-4.6	-0.182	**-4.7
Cross-terms (3, 8)	0.009	1.1	-0.055	**-4.8
Cross-terms (4, 5)			0.036	*2.3
Cross-terms (4, 6)	0.020	**2.5	0.086	**4.9
Cross-terms (4, 7)	-0.022	-1.1	-0.024	-0.7
Cross-terms (4, 8)			-0.061	**-5.1
Cross-terms (5, 6)	-0.009	-1.5	-0.027	**-3.3
Cross-terms (5, 7)	0.052	**6.1	0.005	0.4
Cross-terms (5, 8)			0.004	0.6
Cross-terms (6, 7)	0.004	0.3	0.057	*1.9
Cross-terms (6, 8)			0.019	*1.7
Cross-terms (7, 8)			0.005	0.2
σ^2	0.952	8.0	5.960	5.2
γ	0.914	52.6	0.987	205.3
μ	-1.865	-7.1	-4.852	-3.9